PS #4 SSIns Fall 2020
ECE 345/ME 380 M. Oishi

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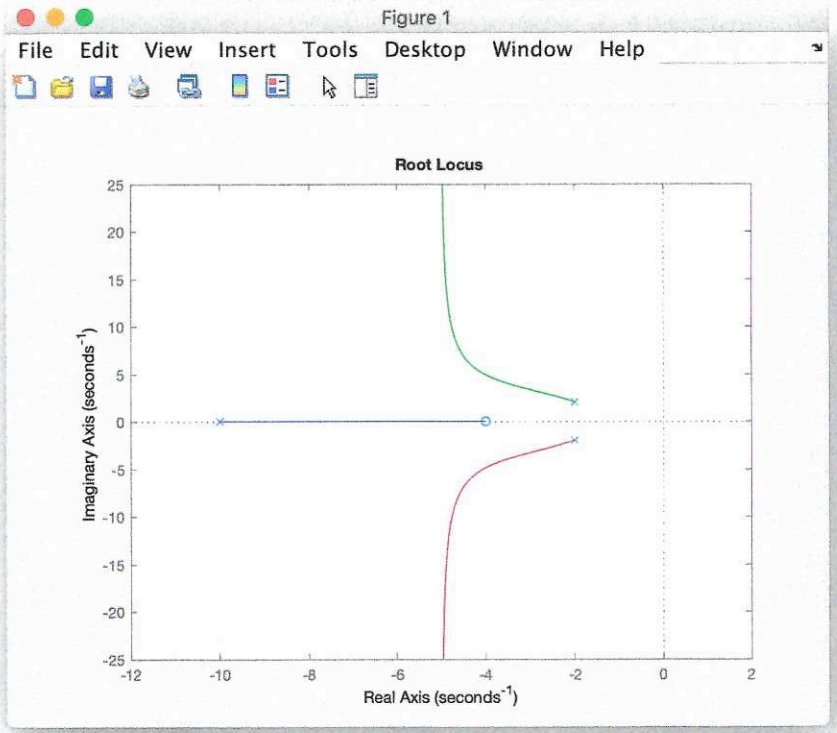
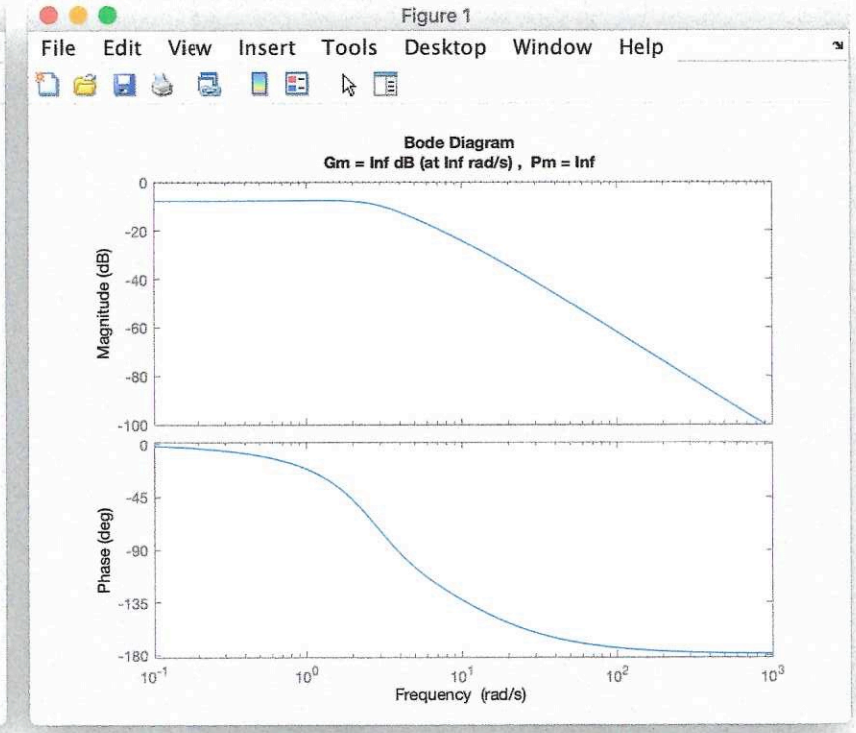
a)



c) Stable w/ $K=1$ because $P_M > 0$ & $G_M > 0$ dB.



b) $\Delta(s) = D(s) + kN(s)$

$= (s^2 + 4s + 8)(s+10) + 8k(s+4)$

$= s^3 + 14s^2 + (48+8k)s + (80+32k)$

Hurwitz criterion: $a_0, a_1, a_2 > 0$ for $k > 0$.

$a_1 a_2 - a_3 > 0$

$(48+8k)14 - (80+32k) > 0$

$(6+k)14 - (10+4k) > 0$

$74 + 10k > 0$

$k > -7.4 \Rightarrow \boxed{k > 0.}$

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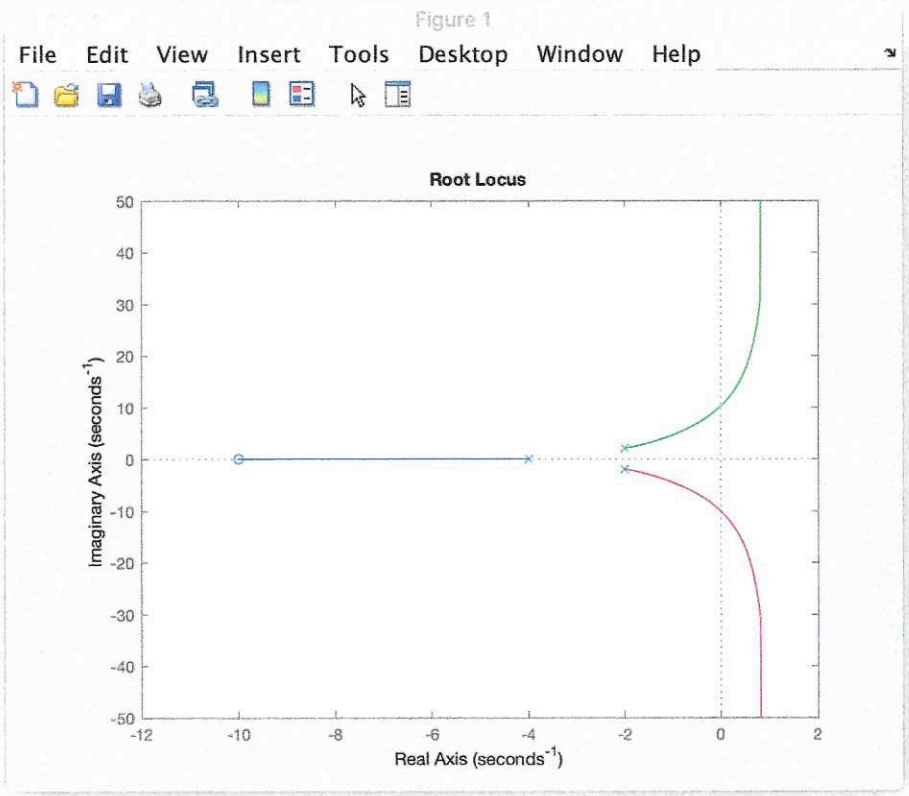
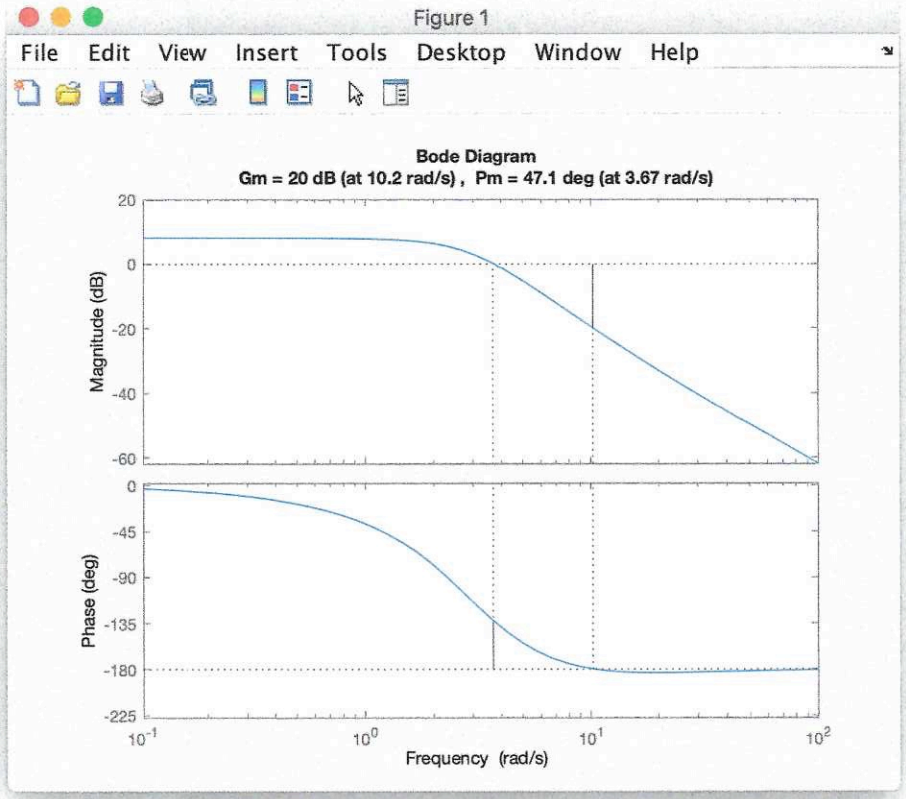
a)



c) Stable with $K=1$ since $P_m > 0°$, $G_m > 0$ dB



b) $\Delta(s) = D(s) + KN(s)$

$= (s^2+4s+8)(s+4) + 8k(s+10)$

$= s^3 + 8s^2 + (24+8K)s + (32+80k)$

Hurwitz criterion: $a_0, a_1, a_2 > 0$ for $k > 0$

$a_1 a_2 - a_0$

$(24+8k)\cdot 8 - (32+80k) > 0$

$(3+k)8 - (4+10k) > 0$

$20 - 2k > 0$

$10 > k$

d) $G_M = 20\,dB = 20 \log x$

$\Rightarrow G_M = 10$, same as value in 2(b) $\longrightarrow$

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a) order = $n-m$ = 2 for lead + lag

asymptotes = 2 for lead + lag.

$$\sigma = \frac{\sum p_i - \sum z_i}{n-m} \Rightarrow \sigma_{lead} = \frac{(-2-2-10)-(-4)}{2} = -5.$$

$$\sigma_{lag} = \frac{(-2-2-4)-(-10)}{2} = +1.$$

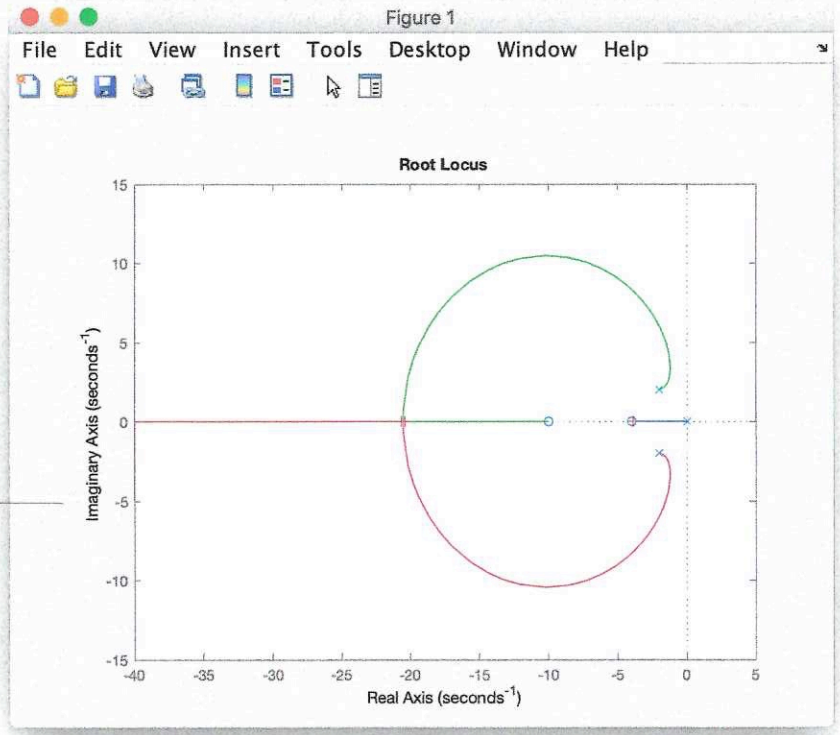
The effect of reversing the pole + zero is the change in the location of the asymptotes (from -5 to $+1$). Lead control moves the centroid to the left; lag moves the centroid to the right (i.e., compare -2 to -5 & -2 to $+1$).

b) Lead control provides more relative stability since phase & gain margin are larger than they are for lag control.

It is impossible to destabilize the system under lead control, but it is possible to destabilize the system under lag control.

[4]

a)



b) With this point, $K = 5.1215$ to make poles co-located at $s = -20$.

c) The locus lies entirely in the open LHP, so it is not possible to de-stabilize the closed-loop system w/ any gain $K > 0$.

```
>> sysLead = tf(8*[1 4], conv([1 4 8],[1 10]));

>> rlocus(sysLead)

>> margin(sysLead)

>> sysLag = tf(8*[1 10], conv([1 4 8],[1 4]));

>> rlocus(sysLag)

>> margin(sysLag)

>> sysPID = tf(8*conv([1 10],[1 4]), [1 4 8 0]);

>> rlocus(sysPID)

>> rlocfind(sysPID)
Select a point in the graphics window

selected_point =

 -20.4058 - 0.0000i


ans =

    5.1215
```